EtherCAT User's Manual

(Version: V1.01)

ESTUN AUTOMATION TECHNOLOGY CO., LTD.

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Version update history

Date	version	description	Author
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Content

Chapter 1 Brief introduction of EtherCAT 1
1.1 What is EtherCAT 1
1.2 EtherCAT general introduction 1
1.3 Product introduction 1
1.4 CoE terms 1
1.5 Data type 2
1.6 Communication specifications 3
1.7 EC-100 module structure 4
1.8 LED indicators 4
Chapter 2 Installation and connection 7
2.1 Installation and connection 7
2.2 EtherCAT interface specification 7
2.3 Wire specification 8
Chapter 3 EtherCAT-EC information 9
3.1 CANopen over EtherCAT model 9
3.2 EtherCAT slave information 10
3.3 EtherCAT network state machine 10
3.4 PDO mapping 11
3.5 Emergency message 13
Chapter 4 Network synchronization based on distributed clocks 14
Chapter 5 CiA402 device protocol 16
5.1 CANopen over EtherCAT(CoE) state machine 16
5.2 Parameters for device control 17
5.2.1 controlword 18
5.2.2 statusword 19
5.2.3 shutdown_option_code 21
5.2.4 disable_operation_option_code 21
5.2.5 quick_stop_option_code 22
5.2.6 halt_option_code 23
5.2.7 fault_reaction_option_code 23
5.3 Control mode 24
5.4 Control mode parameters 24
5.5 Homing mode 26
5.5.1 Control word 26
5.5.2 State word 26
5.5.3 Parameters related to homing mode 27
5.5.4 Homing method 30
5.6 Profile velocity mode 32

5.6.1 Control word 32
5.6.2 State word 33
5.6.3 Parameters related to velocity mode 33
5.7 Profile position mode 37
5.7.1 Control word 37
5.7.2 State word 38
5.7.3 Parameters related to position control 38
5.7.4 Function description 42
5.8 Interpolation position mode 44
5.8.1 Control word 44
5.8.2 State word 44
5.8.3 Parameters related to interpolation position control 45
5.9 Cyclic synchronous position mode 48
Chapter 6 EtherCAT communication example 49
Appendix: Object dictionary 53

Chapter 1 Brief introduction of EtherCAT

1.1 What is EtherCAT

EtherCAT is an open network based on Ethernet to achieve real time control. It could support high speed and synchronized control. By using efficient network topology, the network structure with too many concentrator and complicated connections are avoided. It is very suitable to use this protocol in motion control and other factory automation applications.

1.2 EtherCAT general introduction

EtherCAT technology breaks the limits of normal internet solution. Through this technology, we don't need to receive Ethernet data, decode the data, and then copy the process data to different devices. EtherCAT slave device could read the data marked with this device's address information when the frame passes this device. As the same, some data will be written into the frame when it passes the device. In this way, data reading and data writing could be done within several nanoseconds.

EtherCAT uses standard Ethernet technology and support almost kinds of topologies, including the line type, tree type, star type and so on. Its physical layer could be 100 BASE-TXI twisted-pair wire, 100BASE-FX fiber or LVDS (low voltage differential signaling). It could also be done through switch or media converters or in order to achieve the combination of different Ethernet structure.

Relying on the ASICs for EtherCAT in the slave and DMA technology that reads network interface data, the processing of the protocol is done in the hardware. EtherCAT system could update the information for 1000 I/O within 30μs. It could exchange a frame as big as 1486 bytes within 300μs. This is almost like 12000 digital output or input. Controlling one servo with 100 8-byte I/O data only takes 100μs. Within this period, the system could update the actual positions and status presented by command value and control data. Distributed clock technology could make the cyclic synchronous error lower than 1μs.

1.3 Product introduction

ProNet servo drive achieves EtherCAT communication through EC100 network module. It is a real time Ethernet communication and the application layer applies CANopen Drive Profile (CiA 402).

Besides supporting the PV, PP, IP and other control mode defined in CANopen DS402, this module also supports CSP control mode. Clients could switch the control mode by changing correspondent parameters. It is available from simple velocity control to high speed high precision position control.

1.4 CoE terms

The tables below lists the terms used in CANopen and EtherCAT.

Abbreviation	Description
APRD	Auto Increment Physical Read: a command of EtherCAT Date link layer.

Abbreviation	Description
APWR	Auto Increment Physical Write: a command of EtherCAT Date link layer.
APRW	Auto Increment Physical ReadWrite: a command of EtherCAT Date link layer.
ARMW	Auto Increment Physical Read Multiple Write: a command of EtherCAT Date link layer.
BRD	Broadcast Read: a command of EtherCAT Date link layer.
BRW	Broadcast Write: a command of EtherCAT Date link layer.
CiA	CAN in Automation
CoE	CANopen over EtherCAT
DC	Distributed Clocks Mechanism to synchronize EtherCAT slaves and master.
ECAT	EtherCAT
EEPROM	Electrically Erasable Programmable Read Only Memory.
ESC	EtherCAT Slave Controller
ESM	EtherCAT State Machine
ETG	EtherCAT Technology Group(http://www.ethercat.org)
EtherCAT	Real-time Standard for Industrial Ethernet Control Automation Technology(Ethernet for Control Automation Technology)
FMMU	Filedbus Memory Management Unit
INIT	INIT state of EtherCAT state machine
LRD	Logical Read: a command of EtherCAT Date link Layer
LWR	Logical Write: a command of EtherCAT Date link Layer
LRW	Logical ReadWrite: a command of EtherCAT Date link Layer
OP	Operational state of EtherCAT state machine
OD	Object Dictionary
PDO	Process Data Object
PREOP	Pre-Operational state of EtherCAT state machine
RXPDO	Receive PDO, i.e. Process Date that will be received by ESC
SAFEOP	Safe-Operational state of EtherCAT state machine
SDO	Service Data Object
SyncManager	ESC unit for coordinated data exchange between master and slaver controller
TXPDO	Transmit PDO, i.e. Process Date that will be transmitted by ESC

1.5 Data type

The table below lists all the data types and their range that will be used in this manual.

Code	Data type	Range
UINT8	Unsigned integer 8	0 to 255
INT8	Integer 8	-128 to +127
UINT16	Unsigned integer 16	0 to 65535
INT16	Integer 16	-32768 to +32767
UINT32	Unsigned integer 32	0 to 4294967295
INT32	Signed integer 32	–2147483648 to +2147483627
STR	string	-

1.6 Communication specifications

EtherCAT communication	**applied communication standard**	IEC 61158 Type12, IEC 61800-7 CiA402 Drive Profile
	Physical layer	100BASE-TX (IEEE802.3)
	Interface	• CN5 (RJ45): EtherCAT Signal IN • CN6 (RJ45): EtherCAT Signal OUT
	Wiring	Level-5 twisted pair wire
	SyncManager	• SM0: output mailbox, SM1: input mailbox • SM2: input process data, SM3: Output process data
	FMMU	• FMMU0: mapped to output area of process data(RXPDO) • FMMU1: mapped to transmit area of process data(TxPDO) • FMMU2: mapped to mailbox status
	EtherCAT Commands (Data Link Layer)	APRD, FPRD, BRD, LRD, APWR, FPWR, BWR, LWR, ARMW, FRMW **Note:** APRW, FPRW, BRW, LRW Commands are not supported.
	PDO data	Dynamic PDO mapping
	Mailbox (CoE)	Emergency Message, SDO Request, SDO Response, SDO information **Note:** Don't support TXPDO/RxPDO and remote TxPDO/RxPDO.

	Distributed data(DC)	Free-run, DC mode(activated by configuration) supported DC cycle time: 250us – 2ms
	SII	256 bytes(read only)
	LED light	• EtherCAT system indicator(SYS)×1 • EtherCAT run indicator(RUN)×1 • EtherCAT error indicator(ERR)×1
CiA402 Drive Profile		• Homing mode • Profile position mode • Profile velocity mode • Cyclic synchronous position mode

1.7 EC-100 module structure

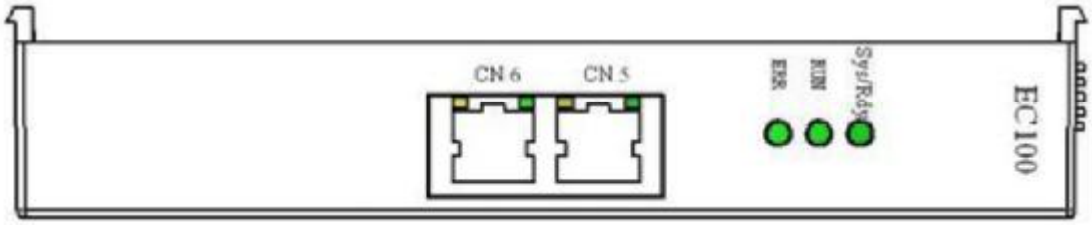
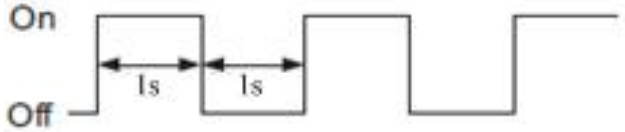


Figure 1-1 Module structure

1.8 LED indicators

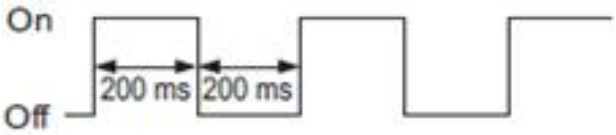
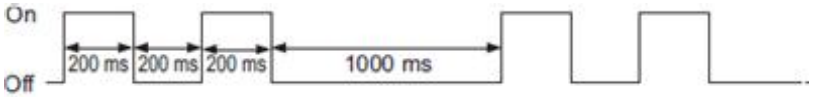
SYS

EC-100 module indicates light, used to show the software status in the module.

LED light(green/yellow)		**Introduction**
Status	**Description**	
Off	Continuously off	No power supply or reset status
Flashing(yellow)		Boot mode
On (green)	Continuously on	Module's internal program has finished initiation and operates well.

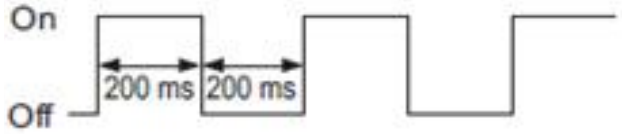
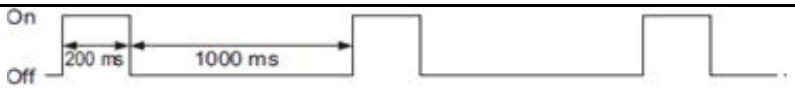
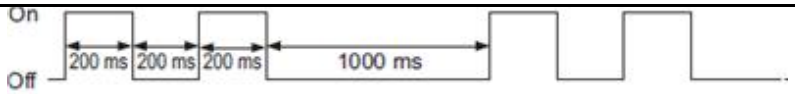
RUN

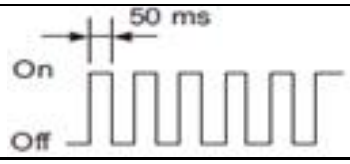
RUN light is used to indicate the communication status of EtherCAT

LED indicator(green)		Introduction
Status	**Description**	
Off	Continuously off	System initiation
Blinking		pre-operation status
Double flashing		safety operation mode
On	Continuously on	Operation status

ERR

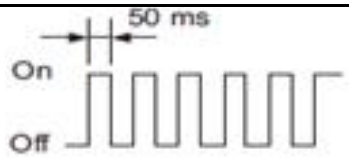
ERR light is used to indicate the error in EtherCAT communication.

LED light(red)		Introduction
Status	**Description**	
Off	Continuously off	No error
Blinking		Due to register problem or object configuration problem, the status changing required by the master couldn't be achieved.
Single flash		Sync error. Communicatio n data error
Double flash		Application program supervision overtime. SyncManager watchdog overtime

Flickering		Initiating error
On	Continuously on	PDI supervision overtime

LINK/ACT (green light on RJ45 COM1/COM2)

LINK/ACT light is used to indicate the physical communication and if there is data exchange.

LED light(green)		**Introduction**
Status	**Description**	
Off	Continuously off	Physical level communication has not been started. EtherCAT controller has not been started.
Flickering		slave is exchanging data
On	Continuously on	There is connection in link layer but there is no date exchange

Chapter 2 Installation and connection

2.1 Installation and connection

EtherCAT network is normally composed of one master (for example, industrial PC) and some slaves (for example, servo drives, filed bus terminals and so on). Every EtherCAT slave has two standard Ethernet interfaces.

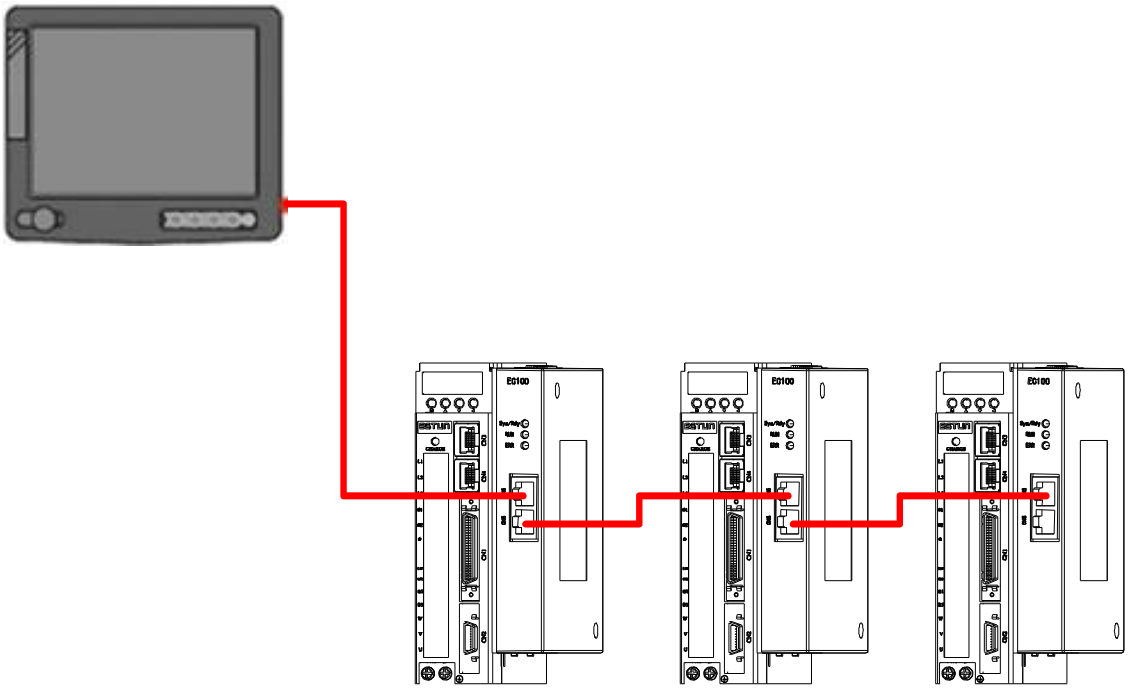


Figure 2-1 EtherCAT network

2.2 EtherCAT interface specification

EtherCAT interface should be connected by twisted pair wire

Electrical feature: according to IEEE802.3 standard

Interface: RJ45 8 pin modularize connector (According to ISO 8877)

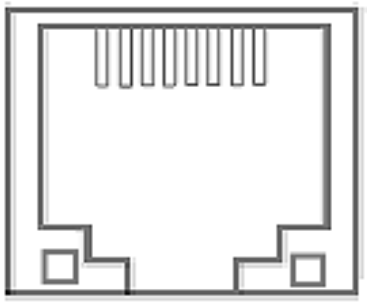


Figure 2-2 RJ45 connector

RJ45 connector

connector	description
CN5	EtherCAT IN port
CN6	EtherCAT OUT port

Pin layout

Pin No.	Signal name	abbreviation	signal transmit direction
1	Data transmit +	TD +	Output
2	Data transmit –	TD-	Output
3	Data receive +	RD+	Input
4	Not used	–	–
5	Not used	–	–
6	Data receive –	RD-	Input
7	Not used	–	–
8	Not used	–	–
Interface grounding	grounding	FG	–

2.3 Wire specification

- Level 5 or above.
- Shield

Note: Identify the cable model is suitable for the interface. Identify items are as follows: conductor specification, single cable/pair cable, two pair/ four pair, external diameter etc.

Chapter 3 EtherCAT-EC information

3.1 CANopen over EtherCAT model

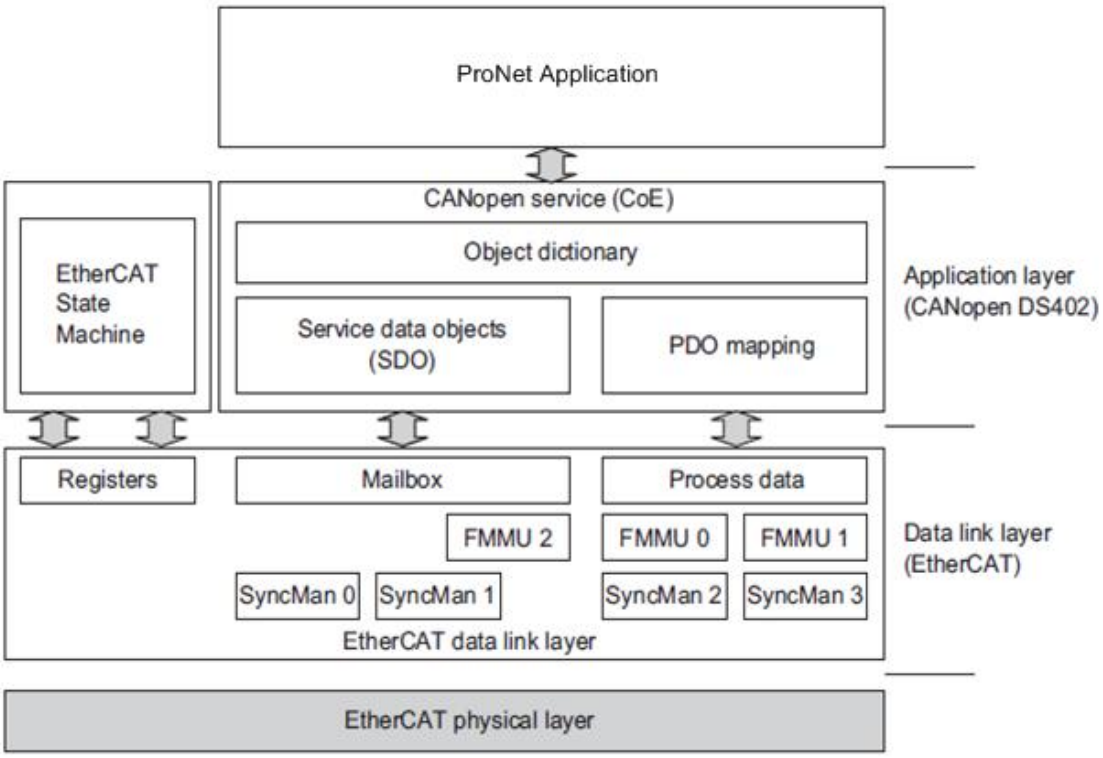


Figure 3-1 Communication model

EtherCAT (CoE) network model is composed of two parts: data link layer and application layer. Data link layer is mainly in charge of EtherCAT communication protocol. Application layer is mainly oriented to CANOpen drive profiles (DS402) communication protocol. Object dictionary in CoE includes parameters, application data and PDO mapping information.

Process data object (PDO) is composed of objects in the object dictionary that could operate PDO mapping. The content of PDO data is defined by PDO mapping. PDO data's read and write are periodical without checking OD. However, mail communication (SDO) is not periodic. When they are read or written, it is necessary to check OD.

Note: To decode SDO data and PDO data on EtherCAT data link layer correctly, we need to configure FMMU and Sync Manager as below

Sync Manager Configuration

Sync Manager	Assignment(Fixed)	Size	Start Address(Fixed)
Sync Manager 0	Assigned to Receive Mailbox	128byte(Fixed)	0x1000
Sync Manager 1	Assigned to Transmit Mailbox	128byte(Fixed)	0x1080
Sync Manager 2	Assigned to Receive PDO	0 to 200byte	0x1100
Sync Manager 3	Assigned to Transmit PDO	0 to 200byte	0x1358

FMMU Settings

FMMU	Settings
FMMU 0	Mapped to Receive PDO
FMMU 1	Mapped to Transmit PDO
FMMU 2	Mapped to Fill Status of Transmit Mailbox

3.2 EtherCAT slave information

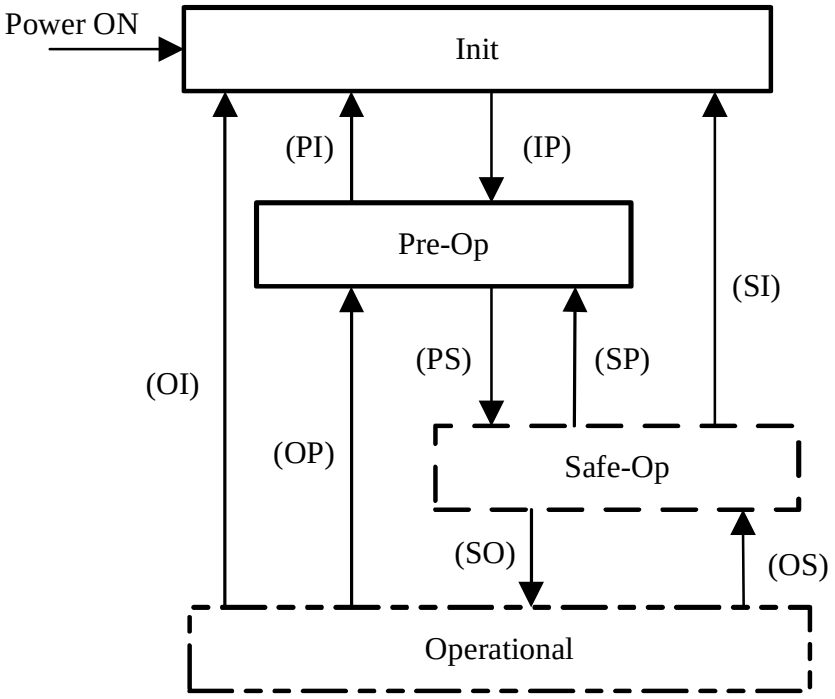
EtherCAT slave information (XML document) could be read by the master to build the master-slave configuration. ESTUN ProNet servo drive offers document as below

ESTUN_ProNet_CoE.xml

3.3 EtherCAT network state machine

EtherCAT state machine is used to describe the states that one slave applies and the state change. State change request is normally launched by the master and answered by the slave.

The graph below describes the slave's state machine.



Status	Description
Init	No mailbox communication No process data communication

Status	Description
Init to Pre-Op	• Master configures data link layer address and initiate mailbox communication • Master initializes DC clock synchronization. • Master requests to change into Pre-op status. • Master sets AL control register. • Slave checks if mailbox initialization is good.
Pre-Operation (Pre-Op)	• Mailbox communication is activated. • Process data communication is not available.
Pre-Op to Safe-Op	• Master configures SyncManager channels and FMMU channels for process data. • Master configures PDO mapping and the sync manager PDO assignment parameters via SDO. • Master requests 'Safe-Operational' state. • Slave checks whether the sync manager channels for process data communication and, if required, the distributed clocks settings are correct.
Safe-Operation(Safe-Op)	Slave's program will transmit actual input data and will not execute output. Output is set as safety status.
Safe-Op to Op	• Master transmits effective output data. • Master asks to change into OP status.
Operational(Op)	Process data communication is available now.

3.4 PDO mapping

Process data of EtherCAT slaves is composed by SyncMangaer channels. Each SyncMangaer channel describes the consistent area of process data. EtherCAT slaves with application control function should support PDO mapping and SM-PDO-Assign object reading.

PDO mapping

PDO mapping is related to the mapping from object dictionary to PDO's application objects (real time process data).

The index 0x1600 and 0x1A00 in object dictionary are separately reserved for the mapping tables of RXPDO and TxPDOs. The graph as below is one example.

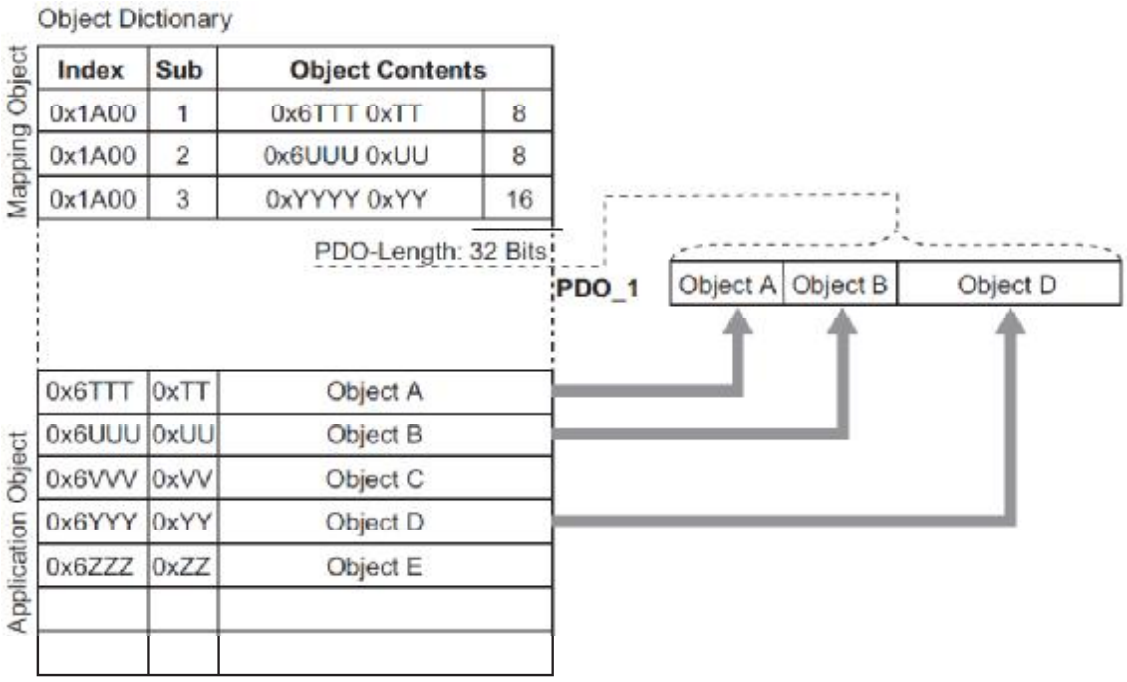


Figure 3-2 PDO mapping example

PDO configuration

Sync manager object (SMCO) is composed of multiple PDOs. SM-PDO-Assign object (0x1C12 and 0x1C13) describes the relationship between PDOs and Sync Manager as below

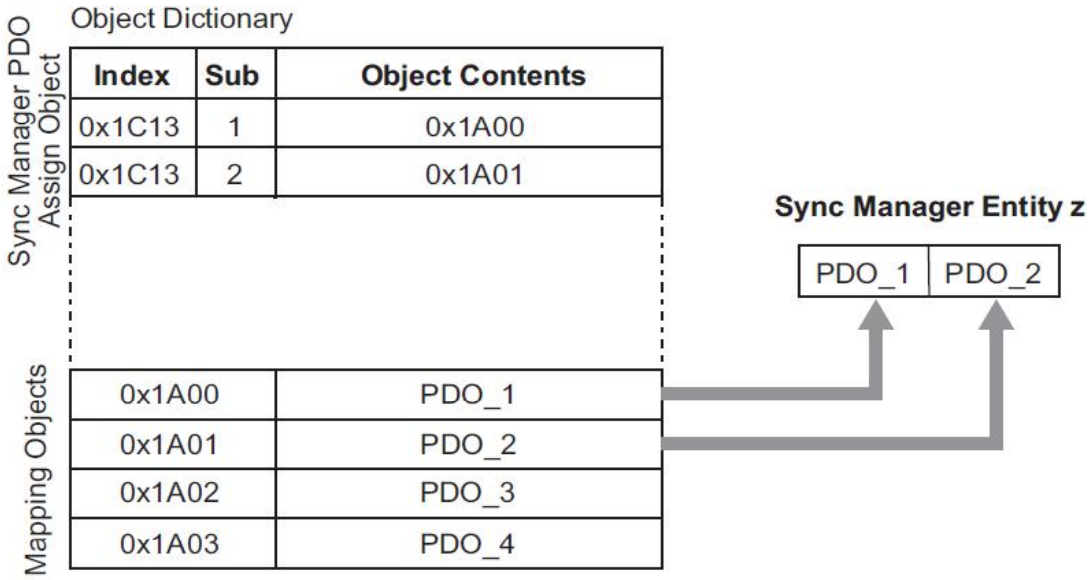


Figure 3-3 PDO configuration example

Note: The PDO mapping objects (index 1600h to 1603h, 1A00h to 1A03h) and the Sync Manager PDO assign objects (Index 1C12h and 1C13h) can be written only in Pre-Operation state.

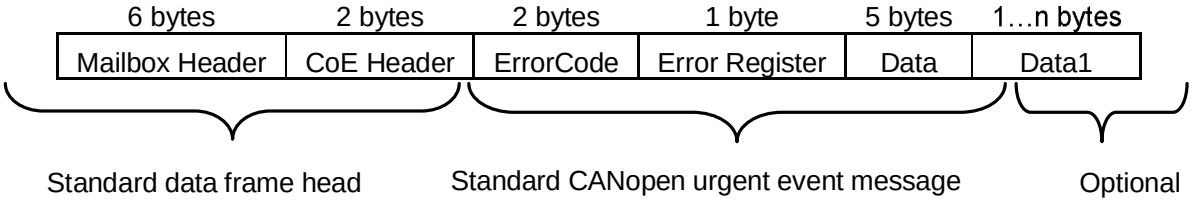
PDO mapping process

1. Stop PDO allocating function (set the sub-index 0 of 0x1c12 and 0x1c13 into 0).
2. Stop PDO mapping function (set sub-index 0 of 0x1600～0x1603 and 0x1A00～0x1A03 into 0).
3. Set the number of mapping entries in PDO mapping objects (Set sub-index 0 of object 0x1600h to 0x1603h/0x1A00h to 0x1A03h).
4. Set the assignment of the Sync manager and PDO (Set sub index 1 of object 0x1C12h and 0x1C13h)
5. Enable the assignment of the Sync manager and PDO (Set sub index 0 of object 0x1C12h and 0x1C13h to 1).
6. Over again open PDO assignment function (set the sub-index 0 of 0x1c12 and 0x1c13 into 1)

3.5 Emergency message

When the servo drive generates an alarm, Coe will activate an emergency message and inform consumers the current servo drive model number and error code.

Emergency message structure:



Byte	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Data	Emergency Error Code		Error Register (Object 1001h)	Reserved	Manufacturer Specific Error Field			
					ProNet Alarm/Warning Code*2		Reserved	

Chapter 4 Network synchronization based on distributed clocks

Any slave in the EtherCAT network can be used as reference clock for the whole network. It provides system time. And the distribute clock in slave device synchronizes with the reference clock. It enables slave's local application to synchronize with reference clock events.

EC-netX50 model achieves the synchronous mode as following. Switching synchronous mode can be controlled by synchronous control register (ESC 0x980 and 0x981).

- Free-Run mode (ESC register: 0x980 = 0x0000)
  In this mode, local application cycle, communication cycle and master cycle is independent.
- DC mode (ESC register: 0x980 = 0x0300))
  In this mode, local application is synchronous with Sync0.

Index	Sub	Name	Access	PDO Mapping	Type	Value
0x1C32	Sync Manager channel 2 (process data output) Synchronization					
	1	Synchronization type	RO	No	UINT	Current status of DC mode ● 0: Free-run ● 2: DC Mode (Synchronous with Sync0)
	2	Cycle time	RO	No	UINT	Sync0 event cycle [ns] (The value is set by master via ESC register.) range: 125000*n (n = 2–16) [ns]
0x1C33	Sync Manager channel 3 (process data input) Synchronization					
	3	Shift time	RO	No	UINT	–
	6	Calc and copy time	RO	No	UINT	–

Time schedule figure in DC mode is as follows:

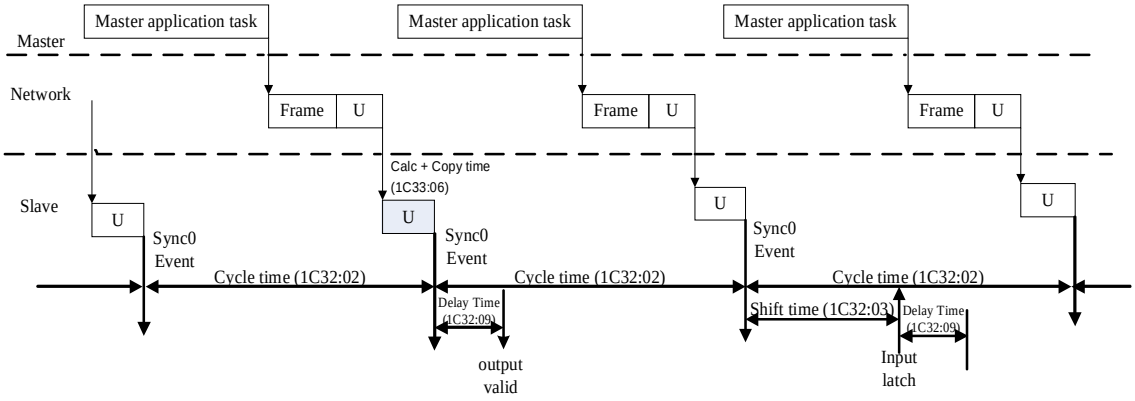


Figure 4-1 Time schedule figure in DC mode

Chapter 5 CiA402 device protocol

ProNet's device control is used mainly to achieve the motion control in different control modes. The master controls the servo drive through control word and knows the status of the servo drive by reading the servo drive's status word.

5.1 CANopen over EtherCAT(CoE) state machine

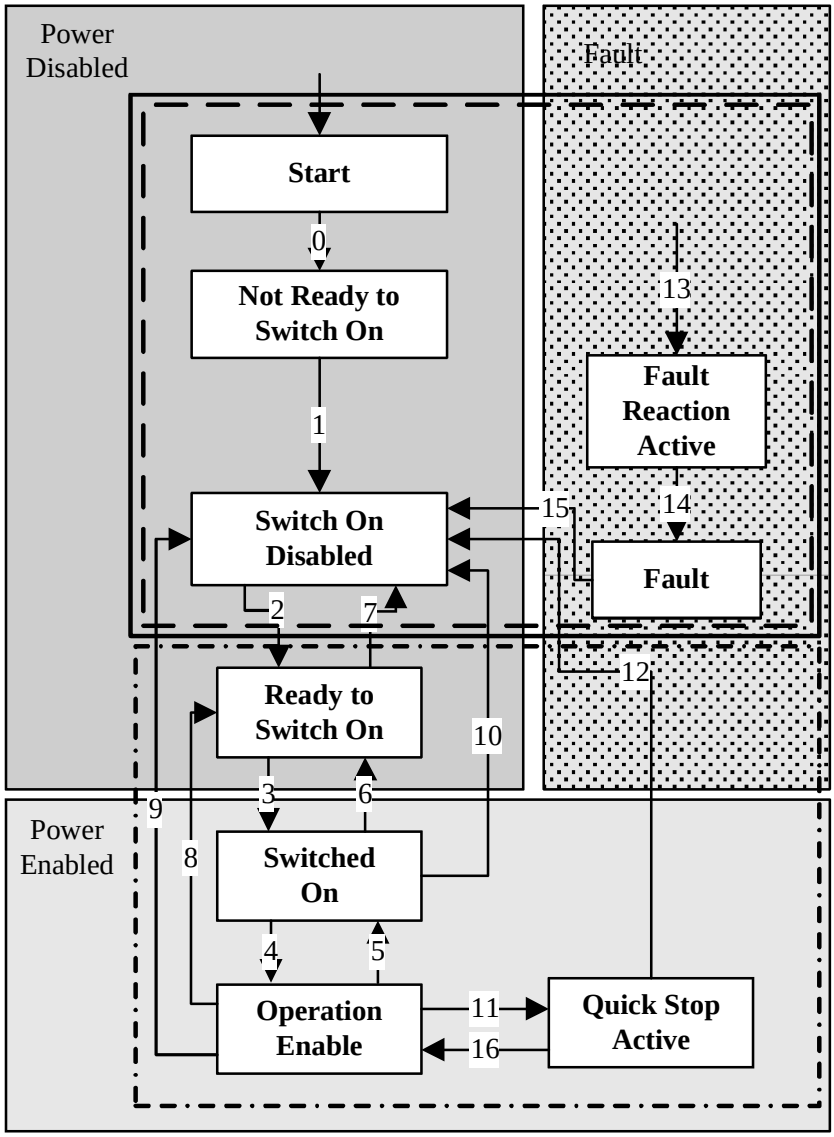


Figure 5-1 CANopen state machine

As above, the state machines could be divided into 3 parts: "power disabled", "power enabled" and "fault". All the states will be into "Fault" status after alarm. After power enabled, servo drive will finish initiating and then enter SWITECH_ON_DISA status. Now we could configure the servo drive, for example, set the working mode of the servo drive as profile position mode.

At this time, the main power supply is still shut down and the servo motor is now excitated. After the state transition 2, 3 and 4, the servo drive will be in OPERATION ENABLE mode. At this time, the main power will be switched on and servo drive starts to control the servo motor according to the configured working mode. So, before this state, we must ensure the servo drive's parameters are correct. State Transition 9 will be used to shut down the main power supply. Once alarm happens to the servo drive, the servo drive's state will be in FAULT state.

States	Description
Not Ready to Switch On	Servo drive is initiating.
Switch On Disabled	Initiation completed.
Ready to Switch On	Servo drive enters Switch On state. The servo motor is not servo-on yet.
Switched On	Servo drive ready and main power is on
Operation Enable	Servo on and control the servo motor according to the control mode.
Quick Stop Active	Servo drive stops in pre-defined method
Fault Reaction Active	Servo drive detects alarm and stop according to pre-defined method. Servo motor is still on.
Fault	Servo off

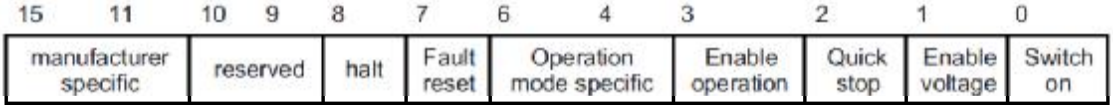
5.2 Parameters for device control

Index	Object	Name	Type	Attr.
6040 $_h$	VAR	Controlword	UINT16	RW
6041 $_h$	VAR	Statusword	UINT16	RO
605A $_h$	VAR	Quick stop option code	INT16	RW
605B $_h$	VAR	Shutdown option code	INT16	RW
605C $_h$	VAR	Disabled operation option code	INT16	RW
605D $_h$	VAR	Halt option code	INT16	RW
605E $_h$	VAR	Fault reaction option code	INT16	RW

5.2.1 controlword

Index	6040 h
Name	Control word
Object Code	VAR
Data Type	UINT16
Access	RW
PDO Mapping	YES
Units	--
Value Range	--
Default Value	0

Control word bit description:



- Bit0 ~ 3 and Bit7:
  The transmission of state machine will be triggered by the command composed by these 5 bits.
  Device control command list

Command	**Bit of the controlword**					
	Fault reset	**Enable operation**	**Quick stop**	**Enable voltage**	**Switch on**	**Transitions**
Shutdown	0	×	1	1	0	2,6,8
Switch on	0	0	1	1	1	3*
Switch on	0	1	1	1	1	3**
Disable voltage	0	×	×	0	×	7,9,10,12
Quick stop	0	×	0	1	×	7,9,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset		×	×	×	×	15

Note: X means this bit could be ignored.

- Bit4, 5, 6, 8:
  In different control mode, these 4 bits' definition will be different.

Bit	Control mode		
	profile position mode	**profile velocity mode**	**homing mode**
4	New set point	reserved	Start homing operation
5	Change set immediately	reserved	reserved
6	abs/rel	reserved	reserved
8	Halt	Halt	Halt

- The other bits: All reserved.

5.2.2 statusword

Index	6041 $_h$
Name	statusword
Object Code	VAR
Data Type	UINT16
Access	RO
PDO Mapping	YES
Units	--
Value Range	--
Default Value	--

Statusword bit introduction is as below

bit	introduction
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop
6	Switch on disabled
7	Warning
9~8	reserved
10	Target reached

bit	introduction
11	Internal limit active
13~12	Operation mode specific
15~14	reserved

- Bit0 ~ 3 , Bit5 and Bit6:
  The combination of these bits represents the status of the servo drive

Value(binary)	State
xxxx xxxx x0xx 0000	Not ready to switch on
xxxx xxxx x1xx 0000	Switch on disabled
xxxx xxxx x01x 0001	Ready to switch on
xxxx xxxx x01x 0011	Switched on
xxxx xxxx x01x 0111	Operation enabled
xxxx xxxx x00x 0111	Quick stop active
xxxx xxxx x0xx 1111	Fault reaction active
xxxx xxxx x0xx 1000	Fault

- **Bit4:** Voltage enabled
  When this bit is **1**, it means the main power is on.
- **Bit5:** Quick stop
  When this bit is **0**, it means the servo drive will stop the servo motor according to the configuration(605A $_h$: quick_stop_option_code)
- **Bit7:** Warning
  When the bit is **1**, it means the servo drive detects alarm.
- **Bit10:** Target reached
  In different control mode, this bit has different meanings.
  - In **Profile Position Mode**, when the set position is reached, this bit will be set as 1. When Halt is activated and speed decreases to zero, this bit will be set as 1. When a new position is set, this bit will be cleared.
  - In **Profile Velocity Mode**, when the speed reaches the required speed, this bit will be set as 1. When Halt is activated, the speed will decrease to zero and this bit will be set as **1**.
- **Bit11:** Internal limit active
  When this bit is **1**, it means that the internal torque has surpassed the set value.
- Bit12, 13:
  These two bits in different control mode have different meaning.

Bit	Control mode		
	profile position mode	profile velocity mode	homing mode
12	Set-point acknowledge	Speed	Homing attained
13	Following error	Max slippage error	Homing error

- The other bits: All reserved

5.2.3 shutdown_option_code

When **Operation Enable** mode is transit to **Ready** to **Switch On** status, Shutdown_option_code will be used to define how to stop the servo motor.

Index	$605B_h$
Name	Shutdown option code
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	NO
Units	--
Value Range	0,1
Default Value	0

value	Introduction
0	Shutdown servo excitation signal. Servo motor will stop freely.
1	After the servo motor decelerates and stops, the servo excitation signal will be shut down.

5.2.4 disable_operation_option_code

When the status of **Operation Enable** transits to **Switched On** status, **disable_operation_option_code** will decide how to halt.

Index	605C $_h$
Name	Disable operation option code
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	NO
Units	--
Value Range	0,1
Default Value	0

Value	Introduction
0	Shutdown servo excitation signal. Servo motor will stop freely.
1	After the servo motor decelerates and stops, the servo excitation signal will be shut down.

5.2.5 quick_stop_option_code

When the **Operation Enable** status transits to **Quick Reaction Active** status, quick_stop_option_code will define how to stop.

Index	605A $_h$
Name	quick_stop_option_code
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	NO
Units	--
Value Range	0,1,2,5,6
Default Value	0

Value	Introduction
0	Shutdown servo excitation signal. Servo motor will stop freely.
1	After the servo motor decelerates and stops, the servo excitation signal will be shut down.

Value	Introduction
2	After servo motor stops urgently, the servo excitation signal will be shut down.
5	After the servo motor decelerates to zero, it will still stay in **QuickStop** status.
6	After the servo motor stops urgently, it will still stay in **QuickStop** status.

5.2.6 halt_option_code

When bit8 of Controlword is 1, halt option code will define how to halt. .

Index	605D $_h$
Name	halt_option_code
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	NO
Units	--
Value Range	1,2
Default Value	0

Value	Introduction
1	Servo motor will decelerate gradually to zero
2	Servo motor will decelerate urgently and then stop.

5.2.7 fault_reaction_option_code

When it alarms, **fault_reaction_option_code** will decide how to halt. .

Index	605D $_h$
Name	fault_reaction_option_code
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	NO
Units	--
Value Range	0
Default Value	0

Value	Introduction
0	The servo excitation signal will be shut down and servo motor will stop freely.

5.3 Control mode

Now, ProNet servo drive supports 5 control modes:

- HOMING MODE
- PROFILE VELOCITY MODE
- PROFILE POSITION MODE
- CYCLIC SYNCHRONIZATION POSITION MODE
- INTERPOLATION POSITION MODE

This chapter will mainly describe these 5 control methods as above.

5.4 Control mode parameters

Index	Object	Name	Type	Attr.
6060 $_h$	VAR	modes_of_operation	INT8	RW
6061 $_h$	VAR	modes_of_operation_display	INT8	RO

modes_of_operation

Servo drive's control mode is defined by modes_of_operation.

Index	6060 h
Name	modes_of_operation
Object Code	VAR
Data Type	INT8
Access	RW
PDO Mapping	YES
Units	--
Value Range	1,3,6
Default Value	0

Value	Introduction
0	Not any control mode
1	PROFILE POSITION MODE
3	PROFILE VELOCITY MODE
6	HOMING MODE
8	CYCLIC SYNCHRONIZATION POSITION

modes_of_operation_display

Servo drive's current control mode could be read from the modes_of_operation_display.

Index	6061 h
Name	modes_of_operation_display
Object Code	VAR
Data Type	INT8
Access	RO
PDO Mapping	YES
Units	--
Value Range	1,3,6,7,8
Default Value	0

Note:

- Only through the parameters of **modes_of_operation_display**, we could get the control mode of the servo drive.

- Only in **Target Reached** status, servo drive's control mode can be transit to configured control mode. And then **modes_of_operation_display** could be the same as **modes_of_operation**.

5.5 Homing mode

PRONET servo drive now supports multiple homing methods. Clients could choose the homing method that suits the motor type and application. For example, if the servo drive uses incremental encoder, we could choose C pulse to do the homing. If the servo drive is using serial encoder or resolver, we couldn't use C pulse as the homing method.

Clients can set homing method, homing speed and acceleration. After the servo drive finds the reference point, we could also set the distance between homing position and reference point as much as the value defined by home_offset (607C $_h$).

5.5.1 Control word

15 ~ 9	8	7 ~ 5	4	3 ~ 0
*	Halt	*	home_start_operation	*

*: please referred to previous chapters

Name	Value	Description
Homing operation start	0	Homing mode inactive
	0 → 1	Start homing mode
	1	Homing mode active
	1 → 0	Interrupt homing mode
Halt	0	Execute the instruction of bit 4
	1	Stop axle with homing acceleration

5.5.2 State word

15 ~ 14	13	12	11	10	9 ~ 0
*	homing_error	homing_attained	*	target_reached	*

*: Please refer to the previous chapters

Name	Value	Description
Target reached	0	• Halt = 0: Home position not reached • Halt = 1: Axle decelerates
	1	• Halt = 0: Home position reached • Halt = 1: Axle has velocity 0
Homing attained	0	Homing mode not yet completed
	1	Homing mode carried out successfully
Homing error	0	No homing error

Name	Value	Description
	1	Homing error occurred; Homing mode carried out not successfully; The error cause is found by reading the error code

5.5.3 Parameters related to homing mode

Index	Object	Name	Type	Attr.
607C $_h$	VAR	home_offset	INT32	RW
6098 $_h$	VAR	homing_method	INT8	RW
6099 $_h$	ARRAY	homing_speeds	UINT32	RW
609A $_h$	VAR	homing_acceleration	INT32	RW

home_offset

Home_offset defines the distance between reference position and homing position.

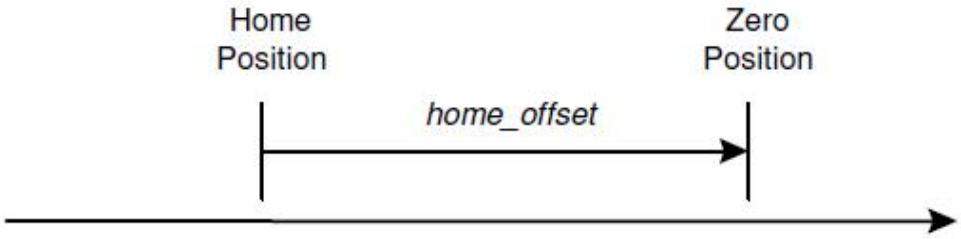


Figure 5-2 Homing mode

Index	607C $_h$
Name	home_offset
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	position units
Value Range	--
Default Value	0

homing_method

There are 4 signals as homing signals: positive limit switch, negative limit switch, reference position switch and C pulse.

Index	6098 $_h$
Name	homing_method
Object Code	VAR
Data Type	INT8
Access	RW
PDO Mapping	YES
Units	--
Value Range	1,2,3,4,17,18,19,20
Default Value	1

Homing method table

Method	Direction	Target position	Reference Position	DS402
1	negative	NOT	C pulse	1
2	positive	POT	C pulse	2
3	negative	reference position switch	C pulse	3
4	positive	Reference position switch	C pulse	4
17	negative	NOT	NOT	17
18	positive	POT	POT	18
19	negative	reference position switch	reference position switch	19
20	positive	reference position switch	reference position switch	20
35	--	currently position	currently position	35

homing_speeds

Two kinds of speed are used in finding the reference position: The speed to find reference position and the speed to find zero position.

Index	6099 $_h$
Name	homing_speeds
Object Code	ARRAY
No. of Elements	2
Data Type	INT32

Sub-Index	01 h
Name	speed_during_search_for_switch
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	0

Sub-Index	02 h
Name	speed_during_search_for_zero
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	0

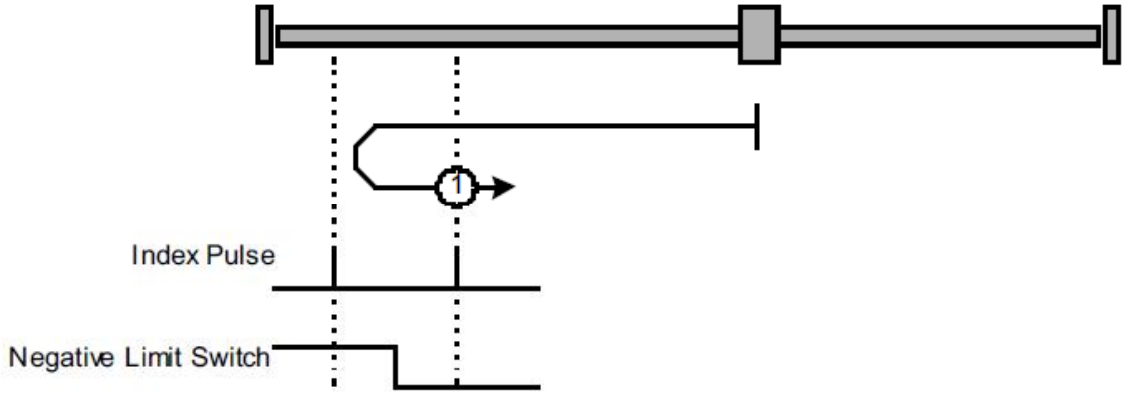
homing_acceleration

Acceleration and deceleration in homing are all defined by homing_acceleration.

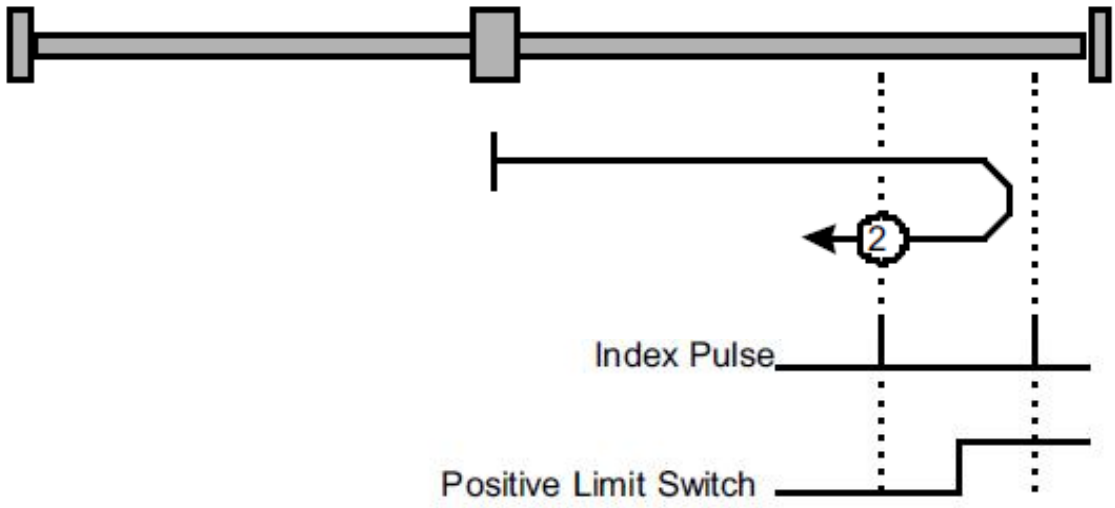
Index	609A $_h$
Name	homing_acceleration
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	acceleration units
Value Range	--
Default Value	0

5.5.4 Homing method

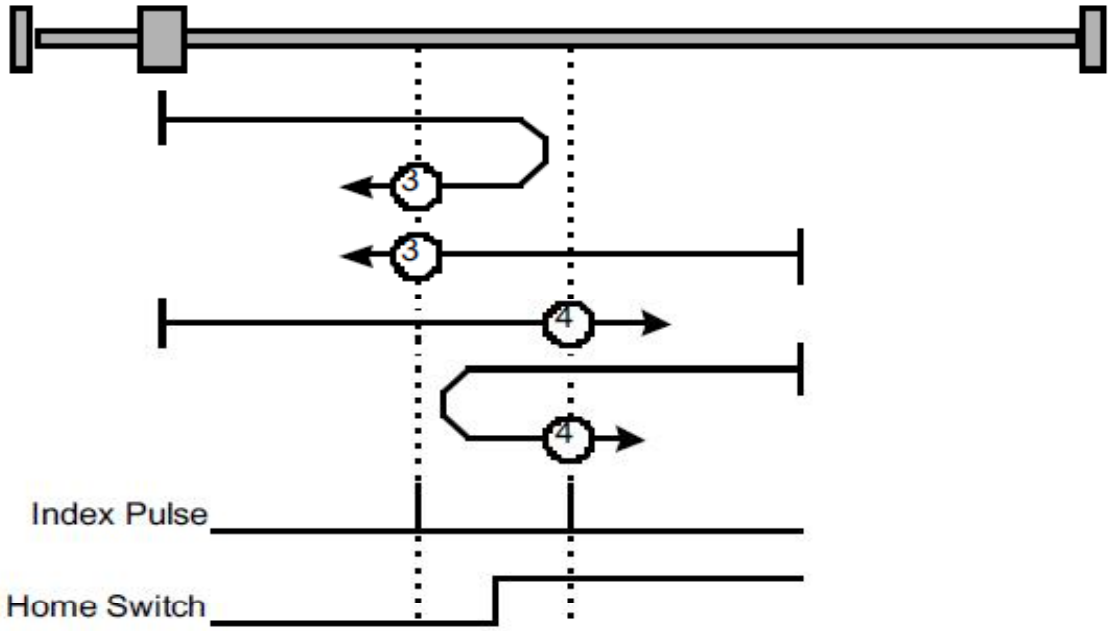
- **Homing method 1**: Use C pulse and negative limit switch
  Servo drive needs to move at first toward negative direction fast till reaching the negative limit switch and then decelerate till stop. And then, servo motor will be bounced back slowly and find the target homing position. Under this homing method, the target homing position is the first C pulse away from the limit switch.



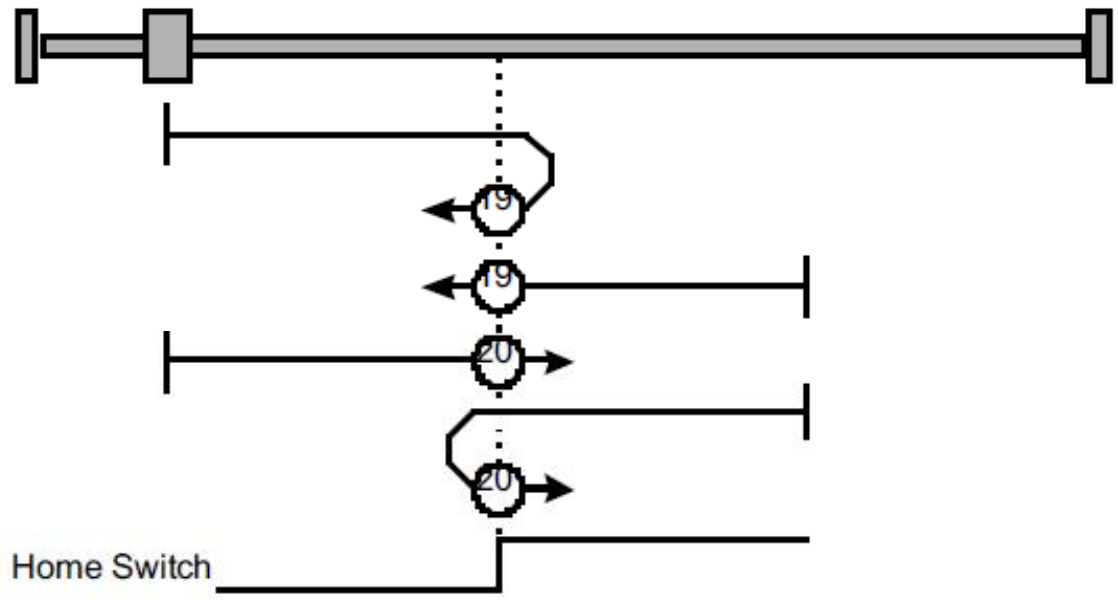
- **Homing method 2**: Use C pulse and positive limit switch
  At first servo motor will move fast toward positive direction and decelerate to stop after reaching the positive limit switch. And then servo motor will be bounced back slowly to find homing position. Under this homing method, the target homing position is the first C pulse away from the limit switch.



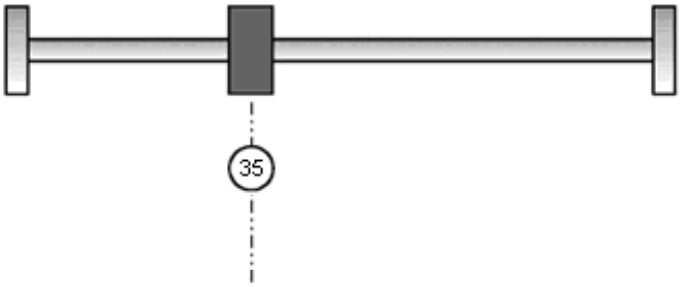
- **Home method 3 and 4**: Use C pulse and reference limit switch
  Servo drive's initial moving direction is relied on the status of reference point limit switch. The target homing position is on the left side or right side of the reference limit switch. The distance between the reference position switch and homing position is one C pulse.



- **Homing method 17 ~ 20** Not to use C pulse
  These 4 homing methods are similar to approach 1-4 but the target homing position is not relied on C pulse any more but on the change of limit switch or reference point. For example, as below, method 19 and method 20 are just similar to method 3 and method 4.



- **Homing method 35**: set current position as the homing point.



5.6 Profile velocity mode

5.6.1 Control word

15 ~ 9	8	7 ~ 4	3 ~ 0
*	Halt	*	*

*: Refer to previous chapters

Name	Value	Description
Halt	0	Execute the motion
	1	Stop axle

5.6.2 State word

15 ~ 14	13	12	11	10	9 ~ 0
*	MaxSlippageError	Speed	*	Target reached	*

*: Refer to previous chapters

Name	Value	Description
Target reached	0	• Halt = 0: Target position not reached • Halt = 1: Axle decelerates
	1	• Halt = 0: Target velocity reached • Halt = 1: Axle has velocity 0
Speed	0	Speed is not equal 0
	1	Speed is equal 0
Max slippage error	0	Maximum slippage not reached
	1	Maximum slippage reached

5.6.3 Parameters related to velocity mode

Index	Object	Name	Type	Attr.
6069 $_h$	VAR	velocity_sensor_actual_value	INT32	RO
606B $_h$	VAR	velocity_demand_value	INT32	RO
606C $_h$	VAR	velocity_actual_value	INT32	RO
609D $_h$	VAR	velocity_window	UINT16	RW
606E $_h$	VAR	velocity_window_time	UINT16	RW
606F $_h$	VAR	velocity_threshold	UINT16	RW
6070 $_h$	VAR	velocity_threshold_time	UINT16	RW
60FF $_h$	VAR	target_velocity	INT32	RW

velocity_sensor_actual_value

The master could read **velocity_sensor_actual_value** to know the current velocity. The parameter's unit is internal speed unit.

Index	6069 $_h$
Name	velocity_sensor_actual_value
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	0.1rmps (1R/10min)
Value Range	--
Default Value	--

velocity_demand_value

Master can read **velocity_demand_value** to know the current reference speed value of the servo drive. The unit of this parameter is user's velocity unit.

Index	606B $_h$
Name	velocity_demand_value
Object Code	VAR
Data Type	INT32
Access	RO
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	--

velocity_actual_value

The master can read **velocity_ actual _value** to know the current velocity of the servo motor. The unit of this parameter is user's velocity unit.

Index	606C $_h$
Name	velocity_actual_value
Object Code	VAR
Data Type	INT32
Access	RO
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	--

velocity_window

The difference between **velocity_actual_value** (606C $_h$) and **target_velocity** (60FF $_h$) is defined as actual velocity error window. If the actual velocity error window is always smaller than **velocity_window**(606D $_h$) within the time set by **velocity_window_time**(606E $_h$), then bit 10 of status word (target_reached) will be set as 1 to indicate that the set velocity has been reached.

Index	606D $_h$
Name	velocity_window
Object Code	VAR
Data Type	UINT16
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	20 R/10min

velocity_window_time

Velocity window comparator is composed of **velocity_window_time** and **velocity_window**.

Index	606E $_h$
Name	velocity_window_time
Object Code	VAR
Data Type	UINT16
Access	RW
PDO Mapping	YES
Units	ms
Value Range	--
Default Value	0

velocity_threshold

Velocity_threshold indicates a range close to zero speed in order to define if the servo motor has already stopped.

Index	606F $_h$
Name	velocity_threshold
Object Code	VAR
Data Type	UINT16
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	10 R/10min

velocity_threshold_time

Velocity_threshold_time is used to set the shortest time when servo motor's speed is under velocity threshold. The unit is: **ms**. When the time that servo motor's speed is lower than the threshold is more than **velocity_threshold_time**, status word bit 12(speed is zero) will be set as **1**.

Index	6070 $_h$
Name	velocity_threshold_time
Object Code	VAR
Data Type	UINT16
Access	RW
PDO Mapping	YES
Units	ms
Value Range	--
Default Value	0

target_velocity

Target_velocity is reference speed.

Index	60FF $_h$
Name	target_velocity
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	0

5.7 Profile position mode

5.7.1 Control word

15 ~ 9	**8**	**7**	**6**	**5**	**4**	**3 ~ 0**
*	Halt	*	abs / rel	change set immediately	New set-point	*

*: Please refer to previous chapters

Name	**Value**	**Description**
New Set-point	0	Does not assume target position
	1	Assume target position

Change set immediately	0	Finish the actual positioning and then start the next positioning
	1	Interrupt the actual positioning and start the next positioning
Abs/rel	0	Target position is an absolute value
	1	Target position is a relative value
Halt	0	Execute positioning
	1	Stop axle with profile deceleration (if not supported with profile acceleration)

5.7.2 State word

15 ~ 14	13	12	11	10	9 ~ 0
*	Following error	Set_point acknowledge	*	Target reached	*

*: please refer to previous chapters

N-ame	Value	Description
Target reached	0	• Halt = 0: Target position not reached • Halt = 1: Axle decelerates
	1	• Halt = 0: Target position reached • Halt = 1: Velocity of axle is 0
Set-point acknowledge	0	Trajectory generator has not assumed the positioning values (yet)
	1	Trajectory generator has assumed the positioning values
Following error	0	No following error
	1	Following error

5.7.3 Parameters related to position control

Index	Name	Type	Attr.	PDO Mapping	M/O
6040_h	Control word	UINT16	RW	YES	M
6041_h	Statusword	UINT16	RO	YES	M
$607A_h$	target_position	INT32	RW	YES	M
$607B_h$	Positin_range_limit	INT32	RW	NO	O
6081_h	profile_velocity	UINT32	RW	YES	M
6082_h	end_velocity	UINT32	RW	YES	O
6083_h	profile_acceleration	UINT32	RW	YES	O
6084_h	profile_deceleration	UINT32	RW	YES	O
6085_h	quick_stop_deceleration	UINT32	RW	YES	O
6086_h	motion_profile_type	INT16	RW	YES	M

target_position

Target_position is reference position and this position could be an incremental value or an absolute value. It is up to bit6 of control word.

Index	607A $_h$
Name	target_ position
Object Code	VAR
Data Type	INT32
Access	RW
PDO Mapping	YES
Units	position units
Value Range	--
Default Value	0

profile_velocity

Profile_velocity is the speed that the servo motor could finally reach after acceleration.

Index	6081 $_h$
Name	profile_velocity
Object Code	VAR
Data Type	UINT32
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	0

end_velocity

End_velocity is the speed when servo motor reaches the **target_position**. Normally we set this value as **0** in order to stop the servo motor when the servo motor reaches the requested position. But in continuous multiple position, this value could be set as a non-zero value.

Index	6082 $_h$
Name	end_velocity
Object Code	VAR
Data Type	UINT32
Access	RW
PDO Mapping	YES
Units	speed units
Value Range	--
Default Value	0

profile_acceleration

Profile_acceleration is the acceleration speed before reaching the target position.

Index	6083 $_h$
Name	profile_acceleration
Object Code	VAR
Data Type	UINT32
Access	RW
PDO Mapping	YES
Units	acceleration units
Value Range	--
Default Value	100000 R/10min/s

profile_deceleration

Profile_deceleration is the deceleration speed before reaching the target position.

Index	6084 $_h$
Name	profile_deceleration
Object Code	VAR
Data Type	UINT32
Access	RW
PDO Mapping	YES
Units	acceleration units
Value Range	--
Default Value	100000 R/10min/s

quick_stop_deceleration

Quick_stop_deceleration is the deceleration speed in Quick Stop.

Index	6085 $_h$
Name	quick_stop_deceleration
Object Code	VAR
Data Type	UINT32
Access	RW
PDO Mapping	YES
Units	acceleration units
Value Range	--
Default Value	200000 R/10min/s

motion_profile_type

Motion_profile_type is used to select the motion curve. Now we only support trapezoid speed curve.

Index	6086 $_h$
Name	motion_profile_type
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	YES
Units	--
Value Range	0
Default Value	0

5.7.4 Function description

There are two methods to allocate a reference position.

Single step setting:

After reaching the target position, servo drive will inform the master that **Reach the target position**. And the servo drive will start new motion after getting new target position. Before getting the new reference position, the velocity of the servo motor is zero.

Continuous setting:

After reaching the target position, the servo motor will keep moving toward next target position which is set in advance. In this way, the servo motor could move continuously without pause. Between two reference positions, the servo motor doesn't need to decelerate to zero.

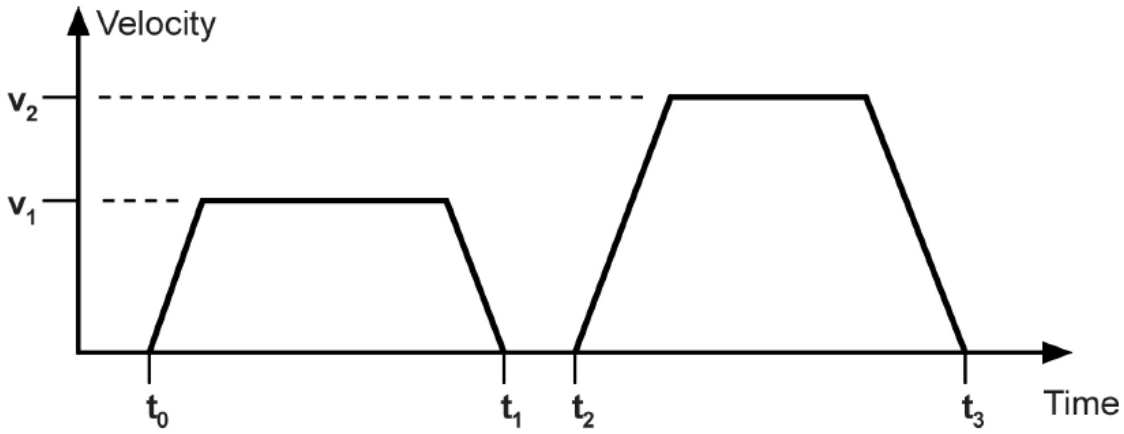
Above two methods could be switched to each other by using control word bit 4, bit 5 and statues word bit 12 (**set_point_acknowledge**) in real time. Through handshaking mechanism, we could pause the position control in the process and use these bits above to reset the target position and then re-active and operate.

Single step setting procedure:

1. At first, set the NMT status into Operational and set the control mode parameter (6060 $_h$) as **1**.
2. According to the actual demand, we could set the target position (**target_positon**: 607A $_h$) and so on.
3. We need set bit4 (**new_set_point**) of the control word as **1**, bit 5 (**change_set_immediately**) as **0**, bit 6 (absolute/comparative) should be determined by whether the reference target position is an absolute value or a comparative value.

4 We use bit12 (**set_point_acknowledge**) of the status word to configure the servo drive acknowledge mechanism. And then we start to operate position control.

5 After reaching the target position, servo drive will need to respond through bit 10 (**target_reached**) of the status word. And then servo drive will follow the program to keep moving or accept new target position.



Continuous step setting procedure:

1 At first, we need to set NMT status into operational and set control mode (6060 h) as 1. According to actual demand, we need to set the first target position (**target_position**: 607A h), target speed, acceleration/deceleration and other relevant parameters.

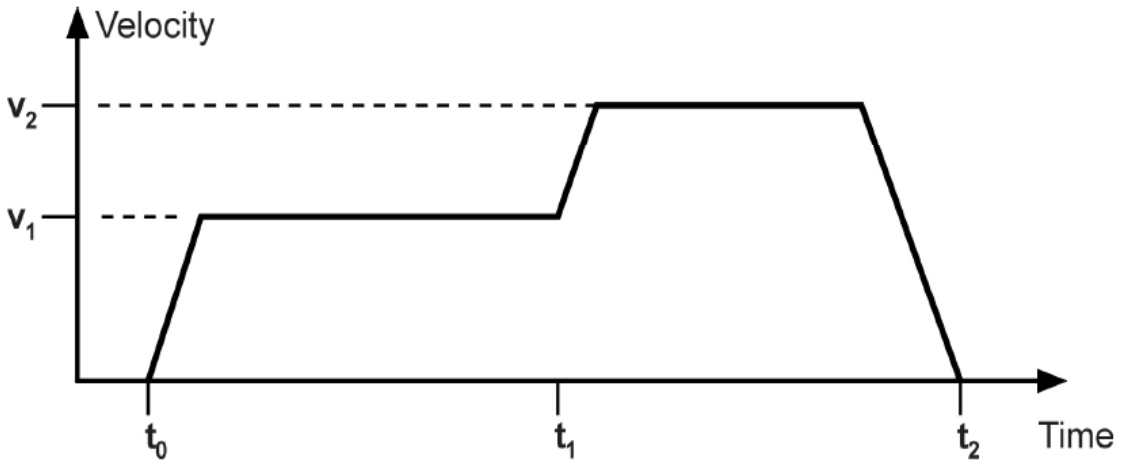
2 Set bit 4 (**new_set_point**) of control word as **1**. Set bit 5 (**change_set_immediately**) as 0. Set bit6 (absolute/comparative) according to the type of object position.

3 Set bit 12 (**set_point_acknowledge**) of the status word and then start to operate position control.

4 Set the second target position (**target_position**: 607A h), target speed, acceleration/deceleration speed.

5 Set bit4 (**new_set_point**) as **1**, bit 5 (**change_set_immediately**) as **0**. Set Bit6 (absolute/comparative) according to the target position type.

6 After reaching the first target position, the servo drive will not stop and keep moving toward the second target position. After reaching the second target position, the servo drive will respond through status word bit 10 (**target_reached**). And then the servo motor will follow the program to keep moving or accept new target position.



5.8 Interpolation position mode

5.8.1 Control word

15 ~ 9	8	7	6	5	4	3 ~ 0
*	Halt	*	*	*	Enable ip mode	*

*: please referred to previous chapters

Name	Value	Description
Enable ip mode	0	Interpolated position mode inactive
	1	Interpolated position mode active
Halt	0	Execute the instruction of bit 4
	1	Stop axle

5.8.2 State word

15 ~ 14	13	12	11	10	9 ~ 0
*	*	ip mode active	*	Target reached	*

*: please referred to previous chapters

Name	Value	Description
Target reached	0	• Halt = 0: Target position not (yet) reached • Halt = 1: Axle decelerates
	1	• Halt = 0: Target position reached • Halt = 1: Velocity of axle is 0
ip mode active	0	Interpolated position mode inactive
	1	Interpolated position mode active

5.8.3 Parameters related to interpolation position control

Index	Object	Name	Type	Attr.
60C0 **h**	VAR	Interpolation sub mode select	INT16	RW
60C1 **h**	ARRAY	Interpolation data record	INT32	RW
60C2 **h**	RECORD	Interpolation time period		RW

Interpolation sub mode select

Interpolation sub mode select is used to select the method of interpolation under IP control. Pronet servo drive only offers linear interpolation.

Index	60C0h
Name	Interpolation sub mode select
Object Code	VAR
Data Type	INT16
Access	RW
PDO Mapping	NO
Value Range	0
Default Value	0
Comment	0: Linear interpolation

Interpolation data record

Interpolation data record is used to reserve interpolation potion data. Our servo drive's interpolation command only uses the first data whose subindex is **1**.

Index	60C1h
Subindex	0
Object Code	ARRAY
Data Type	INT32
Access	RO
PDO Mapping	YES
Value Range	INT8
Default Value	2
Comment	number of entries

Index	60C1h
Subindex	1
Object Code	ARRAY
Data Type	INT32
Access	RW
PDO Mapping	YES
Value Range	INT32
Default Value	0
Comment	the first parameter of ip function

Index	60C1h
Subindex	2
Object Code	ARRAY
Data Type	INT32
Access	RW
PDO Mapping	YES
Value Range	INT32
Default Value	0
Comment	The second parameter of ip function

Interpolation time period

Interpolation time period is used to reserve the time data of interpolation position.

Index	60C2h
Subindex	0
Object Code	RECORD
Data Type	INT8
Access	RO
PDO Mapping	NO
Value Range	2
Default Value	2
Comment	number of entries

Index	60C2h
Subindex	1
Object Code	
Data Type	UINT8
Access	RW
PDO Mapping	YES
Value Range	0~255
Default Value	1
Comment	Interpolation time units

Index	60C2h
Subindex	2
Object Code	
Data Type	INT8
Access	RW
PDO Mapping	YES
Value Range	-4~0
Default Value	-3
Comment	Interpolation time index

5.9 Cyclic synchronous position mode

Cyclic synchronous position mode is similar to position interpolation mode. In this control mode, the master could offer extra speed and torque to achieve speed and torque feed forward control. The interpolation cycle time defines the time for target position updating. In this case, interpolation cycle time is the same as sync time.

Parameters related to CYCLIC SYNCHRONOUS POSITION MODE

Index	Name	Type	Attr.	PDO Mapping	M/O
6040_h	Controlword	UINT16	RW	YES	M
6041_h	Statusword	UINT16	RO	YES	M
6064_h	Position_actual_value	INT32	RO	YES	M
$607A_h$	target_position	INT32	RW	YES	M
$607B_h$	Positin_range_limit	INT32	RW	NO	O
6081_h	profile_velocity	UINT32	RW	YES	M
6082_h	end_velocity	UINT32	RW	YES	O
6083_h	profile_acceleration	UINT32	RW	YES	O
6084_h	profile_deceleration	UINT32	RW	YES	O
6085_h	quick_stop_deceleration	UINT32	RW	YES	O

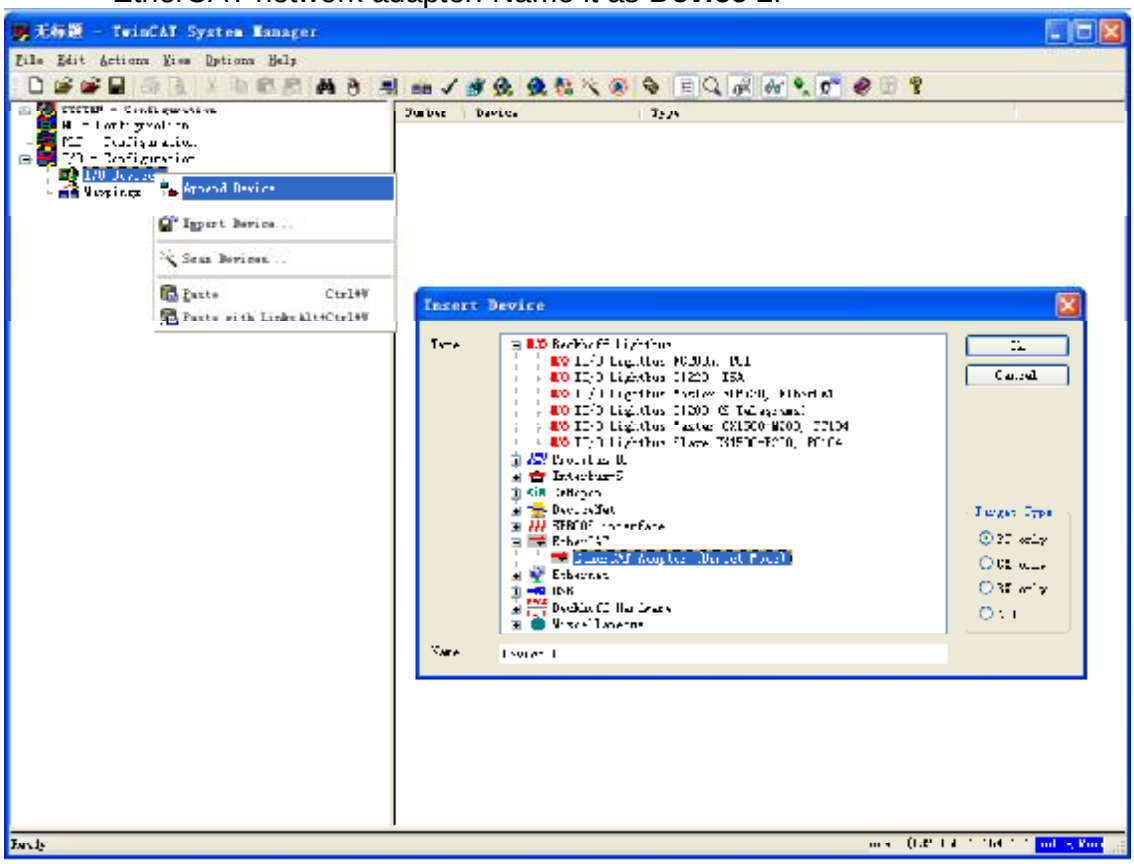
Chapter 6 EtherCAT communication example

In this example, we use Beckhoff TwinCAT software as the real time master. Please prepare as below before the test:

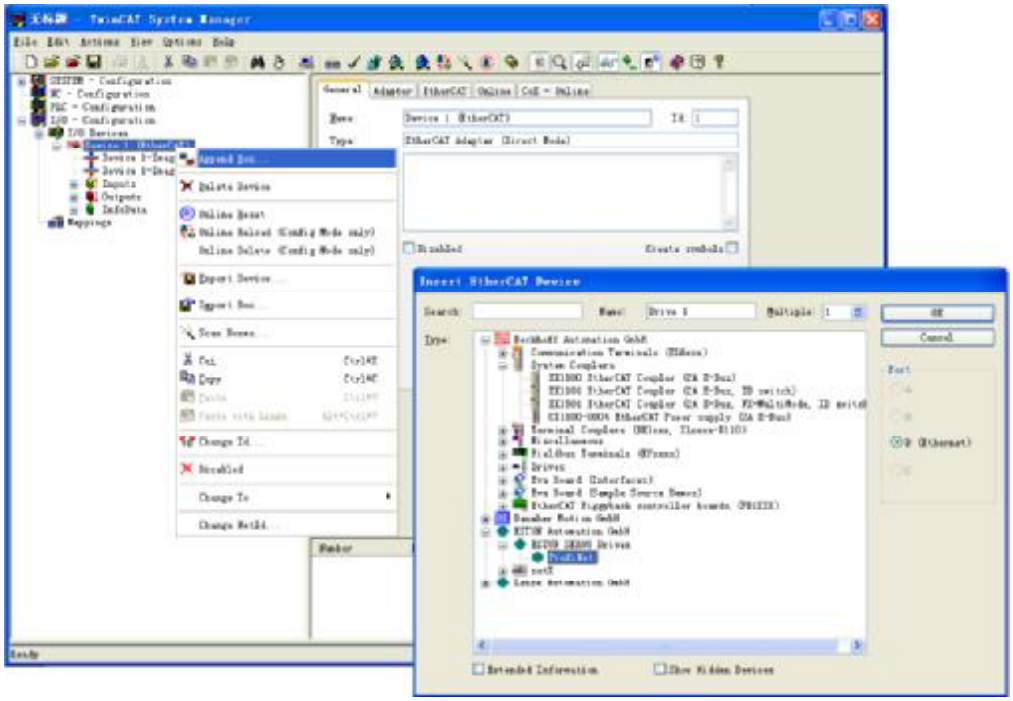
1. 1) Identify the network interface model number and install the network interface correctly.
2. 2) Install Beckhoff TwinCAT software.
3. 3) Copy the device description document (.XML document) to the directory **C:\TwinCAT\IO\EtherCAT**. (You could contact Estun to have this XML document)
4. 4) Set drive's parameter Pn006.0=4, select EtherCAT communication mode, Pn704 is the address.
5. After finishing copying, reactivate TwinCAT software. Then TwinCAT will list an ESTUN ProNet servo drive EtherCAT bus option.

And then please follow steps as below:

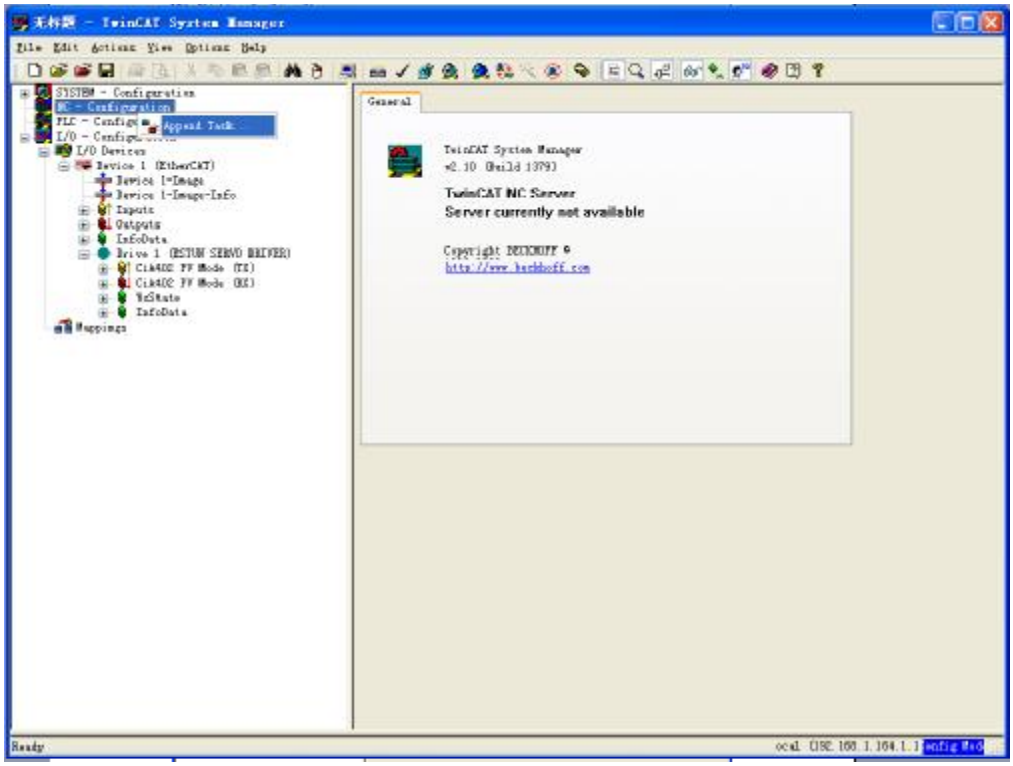
1. Use the right button of the mouse to single click **I/O Device** and choose EtherCAT network adapter. Name it as **Device 1**.



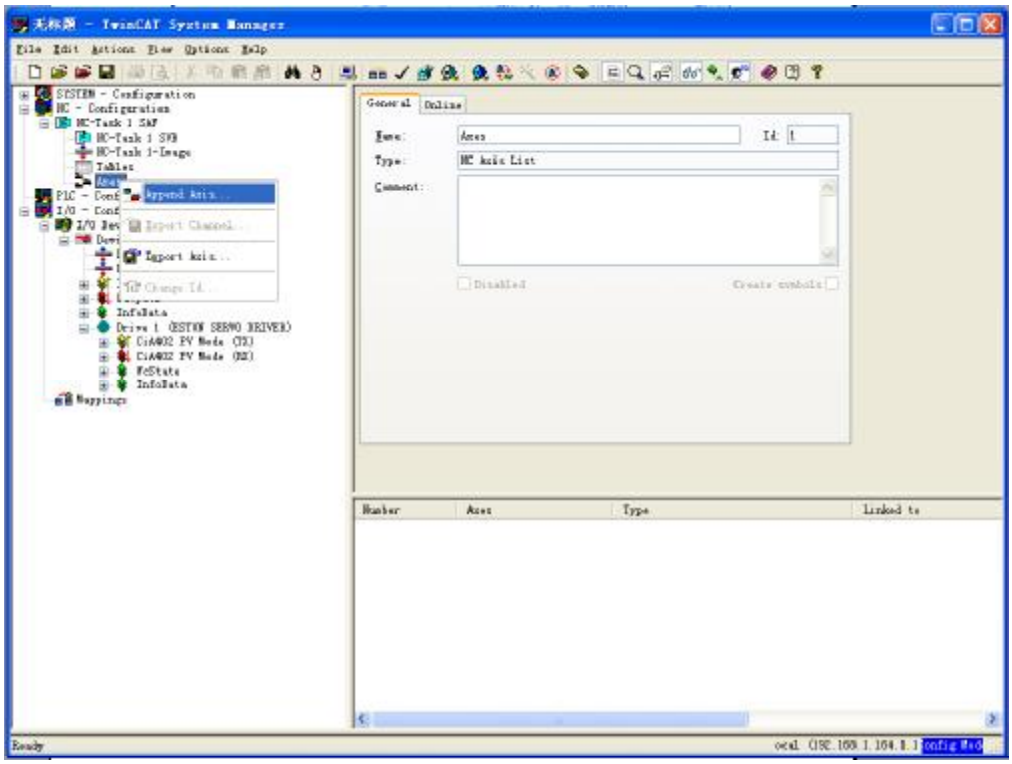
2 Use the right button of the mouse to single click **Device 1** and add a slave ProNet device.



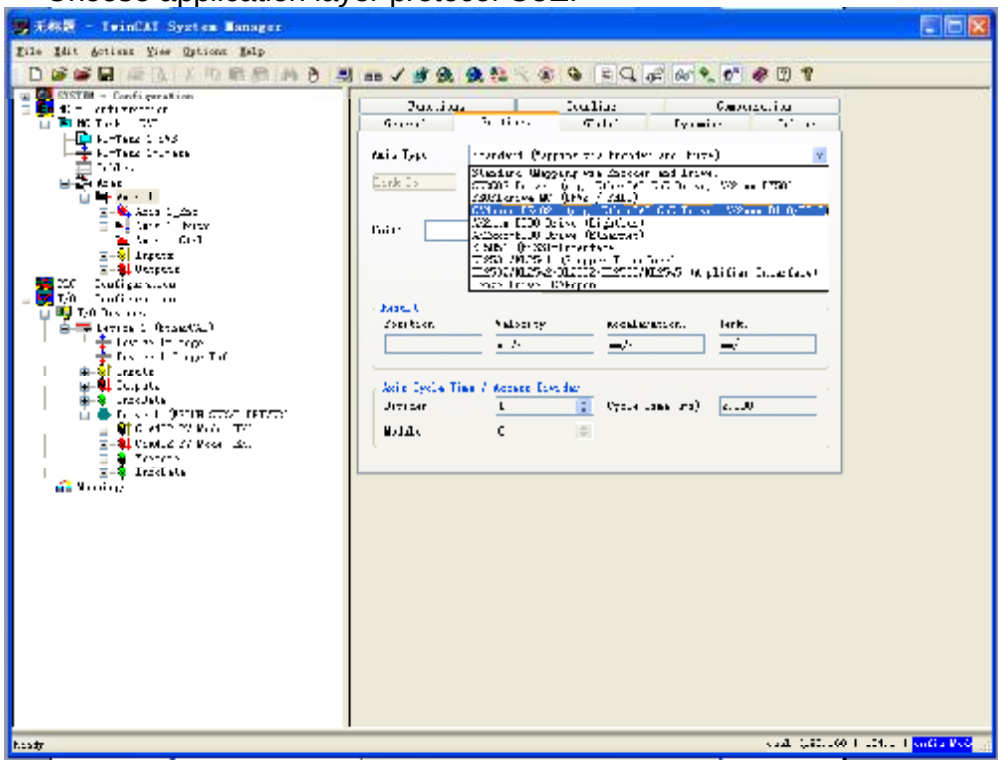
3 3. Add one NC task and name it as **Task 1**.



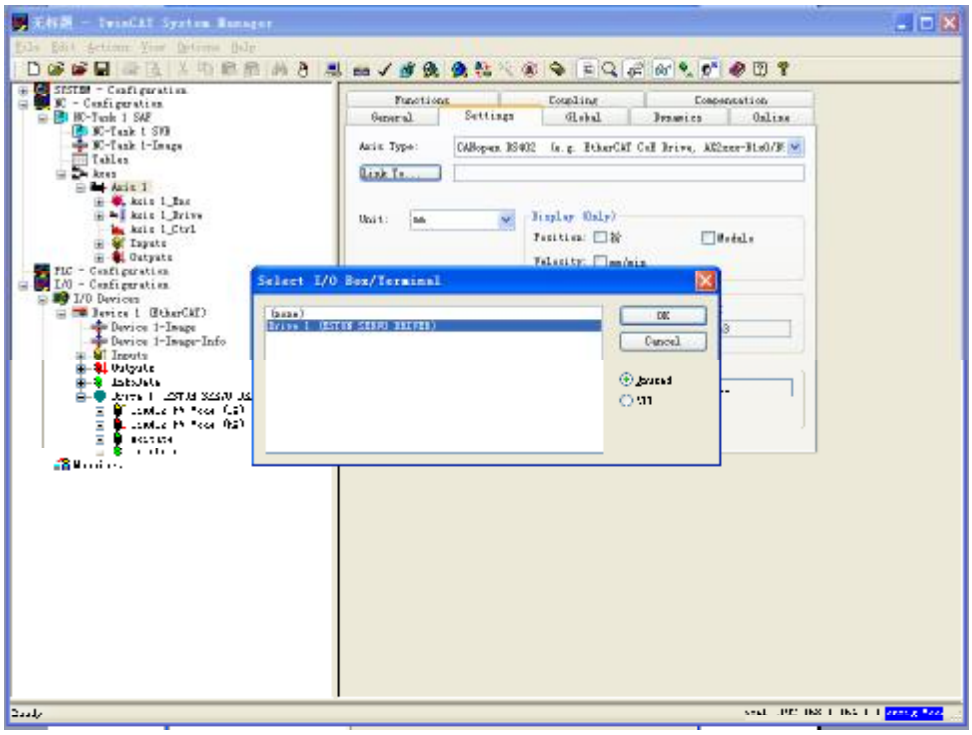
4 Add **Axis 1** under NC task.



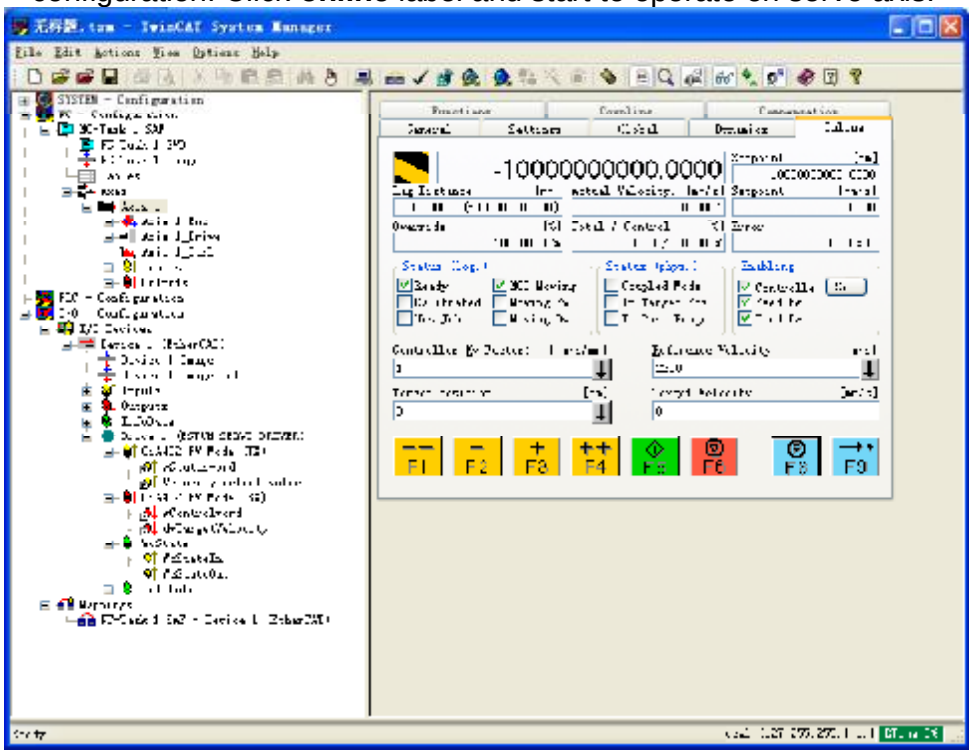
5 Choose application layer protocol **CoE**.



6 Click **Link to** button and map servo drive axis to the device.



7 Click **activate configuration** button on the toolbar and activate configuration. Click **online** label and start to operate on servo axis.



Appendix: Object dictionary

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
1000	0	Device type	UINT32	RO	NO	●						
1001	0	Error register	UINT8	RO	NO	●						
1008	0	Manufacturer device name	STR	RO	NO	●						
1009	0	Manufacturer hardware version	STR	RO	NO	●						
100A	0	Manufacturer software version	STR	RO	NO	●						
1018	Identity Object											
	0	Number of entries	UINT8	RO	NO	●						
	1	Vender ID	UINT32	RO	NO	●						
	2	Product code	UINT32	RO	NO	●						
	3	Revision number	UINT32	RO	NO	●						
	4	Serial number	UINT32	RO	NO	●						
1600	1st Receive PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1601	2nd Receive PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1602	3rd Receive PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1603	4th Receive PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1A00	1st Receive PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1A01	2nd Transmit PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1A02	3rd Transmit PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1A03	4thTransmit PDO Mapping											
	0	Number of entries	UINT8	RW	NO	●						
	1	Mapping entry 1	UINT32	RW	NO	●						
	2	Mapping entry 2	UINT32	RW	NO	●						
	3	Mapping entry 3	UINT32	RW	NO	●						
	4	Mapping entry 4	UINT32	RW	NO	●						
	5	Mapping entry 5	UINT32	RW	NO	●						
	6	Mapping entry 6	UINT32	RW	NO	●						
	7	Mapping entry7	UINT32	RW	NO	●						
	8	Mapping entry 8	UINT32	RW	NO	●						
1C00	Sync Manager Communication Type											
	0	Number of used Sync Manager channels	UINT8	RW	NO	●						
	1	Communication type sync manager 0	UINT32	RW	NO	●						
	2	Communication type sync manager 1	UINT32	RW	NO	●						
	3	Communication type sync manager 2	UINT32	RW	NO	●						
	4	Communication type sync manager 3	UINT32	RW	NO	●						
1C10	0	Sync Manager PDO assignment 0	UINT8	RO	NO	●						

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
1C10	0	Sync Manager PDO assignment 1	UINT8	RO	NO	●						
1C12	Sync Manager PDO assignment 2											
	0	Number of assigned PDOs	UINT8	RW	NO	●						
	1	Index of assigned RxPDO 1	UINT16	RW	NO	●						
	2	Index of assigned RxPDO 2	UINT16	RW	NO	●						
1C13	Sync Manager PDO assignment 3											
	0	Number of assigned PDOs	UINT8	RW	NO	●						
	1	Index of assigned TxPDO 1	UINT16	RW	NO	●						
	2	Index of assigned TxPDO 2	UINT16	RW	NO	●						
603F	0	Error code	UINT16	RW	YES	●						
6040	0	Control word	UINT16	RW	YES	●						
6041	0	Status word	UINT16	RO	YES	●						
605A	0	Quick stop option code	INT16	RW	NO	●						
605B	0	Shutdown option code	INT16	RW	NO	●						
605C	0	Disable operation option code	INT16	RW	NO	●						
605D	0	Stop option code	INT16	RW	NO	●						
605E	0	Fault reaction option code	UINT16	RW	NO	●						
6060	0	Modes of operation	INT8	RW	YES	●						
6061	0	Modes of operation display	INT8	RO	YES	●						
6062	0	Position demand value	INT32	RO	YES		●			●		position units

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
6063	0	Position actual value*	INT32	RO	YES		●			●		inc
6064	0	Position actual value	INT32	RO	YES		●			●		position units
6065	0	Following error window	UINT32	RW	YES		●					position units
6066	0	Following error time out	UINT16	RW	YES		●					ms
6067	0	Position window	UINT32	RW	YES		●					position units
6068	0	Position window time	UINT16	RW	YES		●					ms
6069	0	Velocity sensor actual value	UINT16	RW	YES			●				speed units
606B	0	Velocity demand value	INT32	RO	YES			●				speed units
606C	0	Velocity actual value	INT32	RO	YES			●				speed units
606D	0	Velocity window	UINT16	RW	YES			●				speed units
606E	0	Velocity window time	UINT16	RW	YES			●				ms
606F	0	Velocity threshold	UINT16	RW	YES			●				speed units
6070	0	Velocity threshold time	UINT16	RW	YES			●				ms
607A	0	Target position	INT32	RW	YES		●					position units
607B	Position range limit											
	0	Number of entries	UINT8	RW	NO		●			●		
	1	Min position range limit	INT32	RW	NO		●			●		position units
	2	Max position range limit	INT32	RW	NO		●			●		position units
607C	0	Home offset	INT32	RW	YES		●		●	●		position units
6081	0	Profile velocity	UINT32	RW	YES		●					speed units

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
6082	0	End velocity	UINT32	RW	YES		●					speed units
6083	0	Profile acceleration	UINT32	RW	YES		●	●				acceleration units
6084	0	Profile deceleration	UINT32	RW	YES		●	●		●		acceleration units
6085	0	Quick stop deceleration	UINT32	RW	YES		●	●		●		acceleration units
6086	0	Motion profile type	INT16	RO	YES		●	●		●		
6093	Position factor											
	0	Number of entries	UINT32	RW	NO		●		●	●		
	1	numerator	UINT32	RW	NO		●		●	●		
	2	divisor	UINT32	RW	NO		●		●	●		
6094	--	Velocity encoder factor	--	--	--	●						
	0	Number of entries	UINT32	RW	NO	●						
	1	numerator	UINT32	RW	NO	●						
	2	divisor	UINT32	RW	NO	●						
6097	Acceleration factor											
	0	Number of entries	UINT32	RW	NO	●						
	1	numerator	UINT32	RW	NO	●						
6098	0	Homing method	INT8	RW	YES				●			
6099	--											
	0	Number of entries	UINT8	RW	YES				●			
	1	Speed during search for switch	UINT32	RW	YES				●			speed units

Index	Sub index	Name	Type	Access.	PDO	support						unit
						All	PP	PV	HM	IP	CSP	
	2	Speed during search for zero	UINT32	RW	YES				●			speed units
609A	0	Homing acceleration	UINT32	RW	YES				●			acceleration units
60C0	0	Interpolation sub mode select	INT16	RW	NO					●		
60FA	0	Control effort	INT32	RO	YES		●			●		

Other parameter of servo could be referred to.

Index	Sub index	Object	Name	Type	Access.	PDO	support					unit
							All	CSP	PP	PV	HM	
3022	--	VAR	Pn118	UINT16	RW	NO	●					--
3023	--	VAR	Pn119	UINT16	RW	NO	●					--
3024	--	VAR	Pn120	UINT16	RW	NO	●					--
3025	--	VAR	Pn121	UINT16	RW	NO	●					--
3026	--	VAR	Pn122	UINT16	RW	NO	●					0.1ms
3027	--	VAR	Pn123	UINT16	RW	NO	●					--
3028	--	VAR	Pn124	UINT16	RW	NO	●					--
3029	--	VAR	Pn125	UINT16	RW	NO	●					0.1ms
302A	--	VAR	Pn126	UINT16	RW	NO	●					--
302B	--	VAR	Pn127	UINT16	RW	NO	●					
302C	--	VAR	Pn128	UINT16	RW	NO	●					0.1%

Index	Sub index	Object	Name	Type	Access.	PDO	support					unit
							All	CSP	PP	PV	HM	
302D	--	VAR	Pn129	UINT16	RW	NO	●					r/min
302E	--	VAR	Pn130	UINT16	RW	NO	●					0.1%
302F	--	VAR	Pn131	UINT16	RW	NO	●					r/min
3030	--	VAR	Pn132	UINT16	RW	NO	●					0.1%/1000rpm
3031	--	VAR	Pn133	UINT16	RW	NO	●					
3032	--	VAR	Pn134	UINT16	RW	NO	●					0.1ms
3033	--	VAR	Pn135	UINT16	RW	NO	●					
3034	--	VAR	Pn136	UINT16	RW	NO	●					
3035	--	VAR	Pn137	UINT16	RW	NO	●					0.1ms
3036	--	VAR	Pn138	UINT16	RW	NO	●					0.1ms
3037	--	VAR	Pn139	UINT16	RW	NO	●					0.1ms
3038	--	VAR	Pn140	UINT16	RW	NO	●					r/min
30FF	--	VAR	Pn703	UINT16	RW	NO	●					
3100	--	VAR	Pn704	UINT16	RW	NO	●					

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ESTUN AUTOMATION TECHNOLOGY CO., LTD.

Address: 16 Shuige Road, Jiangning Development Zone
Nanjing 211106, P.R.China
Tel: +86 (0)25-52785866
Fax: +86 (0)25-52785576
Web: www.estun.com
E-Mail: info@estun.com

ESTUN